BRITISH
COLUMBIA

File Number: 410-20/AMBIENT

All Design Manual Holders

June 18, 1999
Engineering Branch
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Re: Implementation of Corridor Ambient Geometric Design Element Guidelines

The Corridor Ambient Geometric Design Element Guidelines Policy has been approved by the MoTH Executive Committee and signed by the Deputy Minister. A photocopy of the signed policy is enclosed with this package for your Design Manual.

Your attention is drawn to the last paragraph of the policy statement which indicates that the Corridor Ambient Geometric Design Element Guidelines apply to all roads under MoTH jurisdiction unless specifically exempted by the MoTH Executive Committee. At the signing of this document the Executive Committee exempted two highway corridors. The only corridors currently exempted from the Corridor Ambient Geometric Design Element Guidelines are:

- The Trans Canada Highway, #1, from Cache Creek to the Alberta Border, known as the CCR (Cache Creek to the Rockies) Project
- The Vancouver Island Highway Project

The following documents are included for insertion behind Tab 13 of your Design Manual:

- A copy of the signed policy statement;
- A White Paper: "Ambient Conditions – Development of the Policy";
- Guidelines for the Preparation of the Ambient Condition Rationale;
- Guidelines for the Development and Preparation of the Project Design Criteria for Construction and Rehabilitation Projects.

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Ministry of Transportation and Highways

Engineering Branch
Geometric Standards and Design Section

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During the year MoTH staff will be working together in implementing this new policy. This process has been intiated through a series of Regional Meetings and will culminate in a MoTH workshop, to be scheduled.

The Engineering Branch will provide support to Regions in the application of this policy and if questions arise where Region desires our input, they should call:

Richard Voyer, P. Eng.
A/Sr. Standards and Design Engineer
(250) 387-7761

Merv Clark
Chief Engineer

Enclosures

CORRIDOR AMBIENT GEOMETRIC DESIGN ELEMENTS GUIDELINES

POLICY

The Ministry will identify highway corridors and within these corridors determine geometric design element dimensions or controls where the highway is performing satisfactorily from the standpoint of traffic safety and efficiency. Those geometric design elements or controls that have proven to provide satisfactory performance on the highway corridor will form the basis to which poor performing sections within the corridor should be designed and upgraded.

This policy will apply to all highway construction and rehabilitation projects. MoTH Executive Committee approval is required to exempt any highway corridors from this policy.

DISCUSSION

Demand for highway upgrading will exceed any reasonable level of funding allocation if all corridors were to be fully upgraded to new highway standards. Upgrading along the full length of corridors will not be possible in the foreseeable future, with the possible exception of a few high volume highways that will be approved by the MoTH executive Committee.

BC highway corridors generally perform well from the point of capacity, efficiency and safety; however, within these corridors there are sections of identified poor performance. These poor performing sections generally have poorer geometry or access controls than the good performing sections of highway along the corridor. These poorer performing sections of highway within the corridor require upgrading to reflect the geometric elements of the acceptably performing length of the corridor, thus providing, "corridor geometric design consistency".

Focusing available funds to correct identified safety or efficiency deficient sections within corridors to the same geometric character as those sections with proven good performance rather than attempting to fully upgrade the whole corridor will result in better network safety and efficiency at given resource levels.

Approved by the Ministry of Transportation and Highways Executive Committee.

Signed original in file ____________________ Signed on March 1, 1999

Deputy Minister

Ministry of Transportation and Highways Date

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WHITE PAPER

Ambient Condition

Development of the Policy

Ministry of Transportation and Highways
British Columbia
Engineering Branch
Feb. 10/99 Revised (layout only) June, 1999

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WHITE PAPER: Ambient Condition, Development of the Policy

INTRODUCTION

This paper describes how a number of recent events has changed the thinking regarding geometric design standards and their application, and how that in turn has caused a review of the MoTH processes of identifying and scoping rehabilitation projects and identifying the appropriate standard to use for such projects.

These events are:

- Changes in thinking of influential bodies such as AASHTO, FHWA and TAC regarding geometric design standards and their application.
- Changes in the Provincial budget for minor capital improvement projects.
- The results of a number of studies of the interrelationships between human factors, design, and safety.

The MoTH policies and procedures that require review are:

- Identifying and determining the scope of minor capital improvement projects, (rehabilitation) and reconstruction projects. These projects are generally funded under one of two budgets; minor capital improvement or rehabilitation.
- Identifying the appropriate geometric standards to use for each individual project.

This paper begins by briefly describing the 4 types of highway improvement projects that are generally recognized by the industry, new construction, reconstruction, rehabilitation (3R) and maintenance. It continues by explaining how the thinking regarding geometric standards and their application have changed ; first by outlining the methods used to establish existing standards; outlining some studies regarding the relationship between standards and safety, and finally describing how the results of these studies has affected the current thinking regarding geometric standards and their application. The paper continues by outlining changes to parts of the MoTH budget and how it has and will affect the scope of some types of projects. The report goes on to discuss the affect of the changes regarding the application of standards and study results has on certain MoTH policies and processes. Finally conclusions and recommendations are made.

DEFINITIONS/DESCRIPTIONS

Highway Improvement Project Types

Highway improvements projects fall into one of four types: new construction; reconstruction; resurfacing, restoration, rehabilitation often referred to as 3R; and maintenance.

New construction, as the name applies, is the construction of a highway where no highway presently exists such as a by-pass.

Reconstruction involves a major change to an existing highway to improve its capacity and/or efficiency. Reconstruction generally falls within the corridor of an existing highway, but in some instances may deviate from the existing alignment.

Rehabilitation; often called 3R for resurfacing, restoration, rehabilitation; is to restore the existing highway to it's initial condition. The project may include some safety enhancements. The primary objective of projects falling under a 3R program is to extend the service life and improve safety of an existing highway.

Maintenance activities typically consist of keeping an existing highway in its current condition.

Budgets

Highway improvement projects are funded from three possible budgets, maintenance, rehabilitation or capital. Each is described briefly below.

- Maintenance budgets, as the name implies, are for the general maintenance of the highway system.

- Rehabilitation budgets are generally spent on activities such as resurfacing and restoration. The projects generally include only minor improvements.

- Capital budgets are used for new construction, reconstruction and rehabilitation. The rehabilitation projects generally include major improvements. The capital budget may be divided into Major Capital and Minor Capital, sometimes referred as Capital Rehabilitation, Capital Reconstruction, or Minor Capital Improvements.

It is interesting to note that the type of project is often identified by the budget from which it is funded rather than the activity. For example a project that involves rehabilitation could be called a capital project or a rehabilitation project, depending upon the source of the funding.

GEOMETRIC DESIGN STANDARDS

Development of Existing Geometric Standards

Current geometric standards have evolved over the past 40 or so years. As quantitative relationships between safety and an individual geometric design element was not well understood the standards have been, for the most part, arrived at by consensus of a committee of knowledgeable, experienced, expert highway designers. As this was a period of rapid expansion of the primary highway system in North America, the geometric standards were developed primarily to aid in the design of new highways. Minor increases in shoulder width or other design elements have a minor impact on the cost of the road in new construction. Therefore a philosophy of bigger is better prevailed with less thought given to the cost effectiveness of the resulting design.

This thinking, along with the lack of understanding of the relationship between standard and safety, lead to geometric standards or elements that are not based on quantitative data, but rather a consensus of the opinions of knowledgeable designers. These elements or standards are a best judgment of a single value taken from a range of values and are appropriate for new construction as intended, although the cost effectiveness in terms of safety is not well established.

The following paragraphs help to verify that the development of standards by AASHTO, TAC, and British Columbia was largely by consensus.

> The following statement is quoted directly from the Transportation Research Board Special Report 214, Designing Safer Roads.
>
> "The American Association of State Highway and Transportation Officials (AASHTO), which has historically assumed primary responsibility for setting design standards used in the United States, relies on committees of experienced highway designers to do this work. The committees use a participatory process that relies heavily on professional judgment. In general, relationships between safety and highway features are not well understood quantitatively, and the linkage between these relationships and highway design standards has been neither straightforward nor explicit. Thus quantitative estimates of the overall safety or cost implications of recommended design policies are not usually developed, although the process takes into account not only safety but also cost and other factors (such as the effect of design on traffic operations and capacity, maintenance implications, and design consistency for similar traffic conditions). "
>
> The Transportation Association of Canada, TAC, uses a similar participatory process involving experience, expert highway designers to develop geometric standards. The committee relies heavily on the AASHTO standards as a basis for the standards, which are modified to recognize Canadian conditions.
>
> The current MoTH Geometric Design Manual relies on both AASHTO and TAC in the development of the standards shown in the manual. Each individual geometric element or standard may have been used directly or altered to recognize conditions unique to British Columbia. Additional standards or geometric elements were also developed to again recognize uniqueness in BC.

During this time of extensive growth of the highway system, a growth that moved the highway system from narrow, low standard, poorly surfaced roads of the pre-war era to modern, high speed, all weather roads, projects were large, extending the length of entire corridors. The need for rehabilitation was not present. The primary highway network, of most Canadian and American jurisdictions are now mature. Many present road works do not result in the full reconstruction of a corridor, but rather are to correct some identified deficiency within a short segment of a corridor, i.e. rehabilitation projects. There are two notable results. The resulting highway corridor consists of sections of varying standards along its length. This results due to the use of the current standard for those 'rehabilitation' projects regardless of the standard to which the highway was built. The second notable point is that the costs of improvements are often high as incremental improvements to some key geometric elements are costly.

Standards and Safety

There is a growing interest in the scientific community regarding highway geometric standards, the vehicle, human factors, and safety. These four areas of study are of special interest.

Highway Elements

Recent US studies have shown that the relationship between incremental improvements to the geometric values of highway elements and improved safety is not linear. That is, the law of diminishing returns applies to many highway elements. For example; on a highway with a lane width of 11 feet the widening of a shoulder from 0 to 2 feet will reduce the relative accident rate by about 0.42. Widening of the shoulder from 2 feet to 4 feet reduces the relative accident rate by a lesser amount, 0.34, while adding 2 feet to an existing 4 foot shoulder reduces the relative accident rate by about 0.27. Thus there is a greater gain in terms of accident reduction by adding smaller widths of shoulder to highways without shoulder, than by adding that same width of shoulder to those highways that have a shoulder. Similar relationships have been found for other highway elements.

Design Consistency

Experienced highway designers know intuitively that an inconsistent design in terms of the geometric elements is not as safe as one that is consistent. There are anecdotal instances where a highway with narrow lanes and shoulders has been widened, with a resulting increase in accidents. The observed reason was that drivers were traveling faster because the road with its wider lanes and shoulders appeared to have a higher design speed than it actually did. The lane and shoulder widths were designed to a higher design speed than were perhaps the longitudinal elements of the roadway, thus it was inconsistent design resulting in some drivers developing an incorrect interpretation of the appropriate operation of a vehicle on that road.

Lamm et al, (XIIIth World Road Congress, 1997) in their work on a highway safety module, identified three requirements for a safe highway; consistency of alignment, harmonization between design and operating speed, and the provision of dynamic safety of driving. Lamm was able to predict accident rates by identifying geometrically inconsistent sections of highway.

Consistency has the strongest links with the human factors of expectancy and workload. In his paper, "Human Factors Issues in Highway Design" Kanellaidis et al states that inconsistency in highway geometric design may arise from, among others, changes in design guidelines and adjacent sections of highway constructed at different times.

There are some important conclusions of these studies. The first is that design consistency, both of the geometric elements themselves and of consistency along a highway corridor is desirable as it results in a safer highway. Therefore care must be taken when doing rehabilitation work to select appropriate values for the geometric elements so as to maintain some level of design consistency along the corridor. The present policy of using the standard of the day for rehabilitation does not accomplish this.

Standards, Current Thinking

A greater understanding of the relationships between safety and design elements as well as other considerations has changed the thinking of agencies responsible for the development of geometric standards. The latest thinking is to suggest a range of suitable values for the various geometric elements rather than define a single value. Thus the standards of the past are becoming guidelines in the future.

The Transportation Association of Canada is in the final stages of rewriting their Manual of Geometric Design Standards for Canadian Roads following this thinking. The manual, expected to be published in the Spring 1999, will have ranges of values called domains, for many of the highway elements. It is significant to note the TAC will also change the name of this new document to "Guide" rather than the present "Standard".

The Transport Research Board published their special report 214, "Designing Safer Roads, Practices for Resurfacing, Restoration, and Rehabilitation". This report deals with the cost effectiveness in terms of improved safety for various incremental design improvements.

The FHWA (Federal Highway Administration) has, in concert with AASHTO, issued a companion book to the AASHTO manual, "A Policy on the Geometric Design of Highways and Streets", often referred to as the Green Book. This FHWA guide, Flexibility in Highway Design, encourages highway designers to expand their considerations when designing with the Green Book and not to apply the criteria listed blindly, but to use it as a guide. A second publication by the FHWA, Flexibility in Highway Design" furthers this encouragement.

US federal law had required that any road built with the help of federal funds be constructed in accordance with Green Book standards. Now this is no longer a requirement.

The State of Vermont has enacted a state law, which allows local officials to depart from conventional AASHTO standards when carrying out design on many State roads.

The city of Phoenix has passed a city ordinance that offers developers the option of constructing narrower streets than standards had required, in future residential developments.

The above examples illustrate that agencies responsible for the development of geometric standards are recognizing that standards are not absolute, and are moving toward suggesting ranges of suitable values for geometric highway elements rather than single values. Thus in the future the road authority and the designer will have the responsibility of selecting the appropriate values for the various geometric elements.

BUDGETS

There is increasing pressure on the highway budget in a number of areas. Growth and development in various areas of the province call for increasing the capacity of sections of the highway network. As MoTH's highway system is a critical element in the support of the provincial and national economy, this need cannot go unfulfilled without negative results on both our economy and well being.

To name a few examples, the Vancouver Island Highway Project will cost in the order of $1.2 billion. Long sections of the Trans Canada Highway between the Alberta border and its junction with Highway 97 to the north are in need of major improvements. Highway 97 in the Okanagan Valley has significant tourist demands with resultant capacity constraints. The Lower Mainland has capacity and corridor problems along both sides of the Fraser River that require major improvements to the highway network. Highway 99 between Vancouver and the Whistler area is in need of a major upgrading.

Another area of concern is that of the large number of bridges which were constructed prior to the mid-1980's and are prone to structural damage in the event of a major earthquake. As the West Coast of BC is in a moderate to high seismic zone with a major earthquake being predicted for the future, seismic upgrade of structures is a priority. This seismic retrofitting of the bridges at risk is estimated at $250 million.

The result of these increasing pressures on the highway budget is that a reasonable level of funding will not meet the demand. Thus the priority and cost effectiveness of projects and associated processes are important to gain the greatest benefit from the funds available.

DISCUSSION

Historically, geometric standards were developed, somewhat intuitively due to the lack of knowledge of the relationship between safety and individual geometric design features, to aid in the design of new highways. Many standards were not developed to achieve a specific level of safety nor were they developed to obtain a specific return in terms of improved safety for moneys invested, but rather arbitrarily based on the intuitive notion that, within certain general limits, larger is safer. Therefore our policy of using the current standard for all minor capital improvement projects may not result in the most cost-effective designs in terms of safety improvements.

Some national agencies responsible for developing geometric design standards have recognized the need to for revision. Singular values for geometric elements are being replaced with a range of suitable values. There is flexibility in the determination of the most appropriate values to use for each geometric value for each individual highway construction project. Again our policy of using the current standard for all construction does not follow current thinking regarding geometric standards.

Geometric design consistency both of the individual design elements and along a corridor results in a safer highway. Therefore the selection of the geometric standard to use for an individual project should be made such that the result is design consistency along the corridor. This may require the use of a standard that is different than the current standard, thus our current policy of using the current geometric standards for rehabilitation projects should be revised.

Historically, the highway network has been in a state of rapid expansion, thus capital works projects covered complete corridors from end to end, thereby achieving corridor consistency in the design. There was little need for rehabilitation. As the Provincial highway system matures there is a greater emphasis on rehabilitation projects. Thus many highway improvement projects do not result in the full reconstruction of a corridor, but rather to correct some identified deficiency within a short segment of a corridor. The present policy of applying the standard of the day to all projects may result in design inconsistencies, an undesirable result.

Incremental improvements to design elements do not always result in equal incremental improvements to safety. They tend to be less, that is an incremental improvement results in a smaller improvement to safety. Therefore to gain the greatest safety improvement to the highway network for a given budget, a greater number of smaller improvements is generally superior to a fewer number of large improvements. Therefore the policy of always applying the standard of the day to all projects may be resulting in a smaller overall improvement to safety.

In general terms there are two criteria used to identify capital improvement projects: identify those sections of highway that are of the lowest standard and reconstruct a portion to the current standard; and identify locations that experience a high number of accidents and rebuild the highway to current standards.

Those projects aimed at improving a section of highway to the current standard is based on the notion that if it is below the current standard, then it is less safe than it should be regardless of its safety record. This results in some rehabilitation projects being undertaken mainly to upgrade to the current standard rather than to address a defined operational problem. This practice will, in some cases, not give good value in terms of safety improvements for the monies spent. Therefore decision criteria for the identification of a safety related design problem and a method to determine the scope of the problem are required.

Those projects aimed at improvement at a high accident location often tend to expand in length far beyond the problem location often based on the above stated notion that a section of highway below the current standard should be upgraded, regardless of it performance record. This could be defined as creeping scope. This results in excess funding being used in a single area and fewer problem areas being addressed within the available budget allocation.

The budgets available for rehabilitation of the provincial highway system have diminished over the last decade. Therefore there is an increasing need to gain the greatest benefit in terms of improved operation and safety from the budget. Projects for rehabilitation must be cost effective, both in terms of identification, scope, and geometric design standard used. Procedures to achieve this are required.

CONCLUSIONS

Two main conclusions result from the above discussion:

1. The current policy of using the standard of the day for all highway construction including rehabilitation projects results in projects that give less than optimum return in terms of safety improvements. Revisions to the present policy are required.

2. There is a greater need to gain the most value from monies spent on rehabilitation. Criteria for the identification of problem areas and procedures for determining the scope of projects are required.

RECOMMENDATIONS

The main goal of the recommendations is to; identify, scope, and design projects that result in the most cost effective capital rehabilitation program in terms improvements to the operations and safety of the highway network as a whole.

To achieve this goal it is recommended that policies and procedures be adjusted/developed that:

- Determine safety performance criteria for the identification of capital rehabilitation projects.

  The majority of the numbered highways have an acceptable level of performance in terms of safety. Within these corridors there are sections whose performance falls below that which is acceptable. Improving those deficient sections to the same level as the acceptable sections would provide design consistency along the corridor as well as good levels of performance at a reasonable cost.

  By identifying those sections of highway within each corridor, or major section there-of, that are operating at the acceptable level of performance and applying the geometric design of those sections, the ambient condition, to deficient sections within that corridor, the resultant designs will be to a standard that has shown to give the acceptable level of safety, achieve design consistency throughout the corridor (in itself achieving greater safety). Thus the standard used will be based on what exists and is working acceptably rather than a theoretical value based somewhat on intuition.

- Develop geometric standards that result in design consistency along highway corridors, have shown to provide an acceptable level of safety, and are cost effective from a network perspective.

  For each corridor an ambient condition will be determined that will reflect the standard to which the corridor has been built and is operating satisfactorily in terms of safety. The design criteria for each project will be determined individually based on the ambient condition defined for the corridor as well as other factors such as the long-term plans for the corridor.

- Address specific, well-defined problems of level of service, operations, and/or safety and restrict the project scope to that required to address the engineering problem that has been identified.

  Each capital rehabilitation project will require a design criteria document. This will include the identification and definition of the specific problem(s) being addressed, the engineering solution to the problem, the scope of the work required to address the problem, and the design criteria (values for the major geometric elements) to be used in the design.

ACTION PLAN

Ambient Condition

A set of design parameters to be used for improvements on each individual corridor or major section thereof will be determined by regional staff. These parameters, called the ambient conditions, will be based on the present standards of portions of the corridor, which have demonstrated acceptable safety performance.

The measure of safety performance that is generally used is the accident rate per million vehicle kilometers. Other measures available are the critical rate, the rate at which there is a significant difference between it and the accident rate, the accident severity ratio which is a weighted measure considering the severity of accidents, and the fatality rate. Generally a section of highway with a high fatality rate or accident severity ratio has specific locations or short sections that require improvement.

It is recommended that the measure for acceptable performance with respect to safety will be the provincial average accident rate for that classification and volume of traffic. Therefore sections of highway which have an acceptable safety performance record will be those that have an accident rate less than the critical rate.

Project Identification and Scope

Each project will be undertaken to correct an identified and defined operational problem. The scope will be limited to the work required to correct the deficiency, i.e. the engineering solution. The accident severity ratio is an aid to identifying locations or sections of highway that have deficiencies. Identifying high accident locations, carefully defining the problem and developing and applying the solution, with a design criteria based on the ambient condition and philosophy of corridor consistency, will address the high accident locations with a cost effective design.

Project Design Criteria

Each project will have the mandate to develop an appropriate standard to be used for that project, based on the ambient condition defined for the corridor but with flexibility so that adjustments can be considered to achieve design consistency and cost effectiveness.

Design Criteria Document

Each design will require the preparation of a Design Criteria Document. This document will identify the operational or safety problems, define the problem and outline the engineering solution. The scope of the project will be described, limited to the work necessary to address the defined problem. The design parameters to be used for the project will be outlined. Project approval will be by appropriate regional staff unless there are exceptions to the ambient condition. These will require approval of the Chief Engineer. The design criteria document will become part of the project file, which is subject to audit.

GUIDELINES FOR THE PREPARATION
of the
AMBIENT CONDITION RATIONALE

Ministry of Transportation and Highways
British Columbia
Engineering Branch
Mar 1/99 – Some editing June 10, 1999

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Introduction

The policy, *Corridor Ambient Geometric Design Elements Guidelines*, states that the Ministry will identify highway corridors, and within those corridors, determine geometric design elements that have been performing well in terms of safety and traffic operation. These geometric elements, collectively called the ambient condition, will be used as the basis for the design parameters for the rehabilitation of poor performing sections of the highway corridor. This document gives guidance to the regions for the determination of the ambient condition and the preparation of the Ambient Condition Rationale. The audience for the Ambient Condition Rationale is the layperson.

Background

Recent studies have indicated two noteworthy aspects of geometric design: consistency of design along a highway corridor tends to be safer than a highway that exhibits inconsistencies, and incremental increases to some geometric elements do not result in corresponding incremental increases to safety.

The following quote from the policy states the rationale for the new policy and the development of the ambient condition.

"BC highway corridors generally perform well from the point of capacity, efficiency and safety; however within these corridors there are sections of identified poor performance. These poor performing sections generally have poorer geometry or access controls than the good performing sections of highway along the corridor. These poorer performing sections of highway within the corridor require upgrading to reflect the geometric elements of the acceptably performing length of the corridor, thus providing , "corridor geometric design consistency.""

Definitions

Corridor: A highway corridor is the highway corridor within the Region.

Section: A section is a portion of a highway corridor that exhibits uniform characteristics of terrain, development/access, and traffic volumes and composition.

Procedural Guidelines for Determining Ambient Condition

The following suggests the general procedures to use to determine the Ambient Condition for each corridor or section thereof. The objective is to determine the existing standard of those portions of the highway within a corridor that are operating satisfactorily from a safety and operational perspective. That standard will be the *basis* for the recommended ambient condition to which those portions that require rehabilitation will be improved.

- Separate each highway corridor into sections, i.e. portions of highway that exhibit uniform characteristics of terrain, development/access and traffic volumes and composition.
- Within each section, identify those portions of highway that have the same apparent design speed, lane width, and shoulder width. Thus each highway corridor will be separated into sections and they in turn into sub-sections exhibiting uniform geometry. Judgement is needed so that small changes or very short sections are not included.
- Next, determine what sections of the highway are generally operating satisfactorily from a safety and operational perspective. For each of the identified sub-sections, determine the Accident Rate, Critical Rate, and Accident Severity Ratio. It may be worthwhile to contact local officials such as the police and the district staff to obtain their opinion as to the performance of the highway, i.e. what sections of the highway is performing satisfactorily and which locations have a safety or operational related problem. There may be specific problematic locations in a section of highway that is otherwise operating satisfactorily.

  Where a regional boundary separates a section of highway that is uniform in terms of terrain, development, access and traffic, discussion should take place between the two regions so as to arrive at the same ambient condition for that section of highway.
- Analyze the data to identify those sections of highway that exhibit a satisfactory safety and operational performance. A satisfactory safety performance will be the provincial average accident rate for the type of highway and volume of traffic. Thus an accident rate that is less than the critical rate will be deemed to be performing satisfactorily. Satisfactory performance from an operational perspective will be based on judgement after discussion with others such as district staff.

  The lowest existing condition that is performing satisfactorily will be the *basis* for the ambient condition for that corridor or section.
- Applying the above principles, Ministry design guidelines, and other relevant considerations, determine the ambient condition appropriate to each highway section. Other relevant considerations could include such things as consistency, or terrain when determining shoulder widths, maximum grades or minimum curves with advisory signing. For example a section of highway with a 1.8 m shoulder may be performing satisfactorily, but the majority of the highway is constructed to a 2 m shoulder. An argument could be made to make the ambient condition include a 2 m shoulder.
- Prepare the Ambient Condition Rationale including the spreadsheet of recommended ambient conditions.
- Forward the Ambient Condition Rationale to the Chief Engineer for sign-off.

Use of the Ambient Condition

The design principle is to use the established ambient condition for all improvements to the highway. Thus the elements of a rehabilitated section will be the same as those of the ambient condition defined for that corridor or section. Project Design Criteria will be prepared for each project using the ambient condition set for that corridor or section, as the basis. The values for the basic geometric elements will be defined in the Project Design Criteria. These values will be based on the ambient condition defined for the corridor/section, but variation from these values is possible with rational explanation.

The following geometric elements will be used to describe the ambient condition.

- Design speed
- Minimum advisory speed curve
- Maximum superelevation
- Maximum grade
- Lane width
- Shoulder width, paved
- Shoulder width, gravel
- Setback distance to utilities

Design speed

The ambient condition will include a design speed which in turn defines certain minimum or maximum geometric elements. When determining the design speed of your existing highways it is expected that this value be arrived at by way of a considered judgement, not a measured value, hence the term apparent.

Minimum Advisory Speed Curve

This is the minimum design speed for a substandard curve that would be tolerated when rehabilitating. Thus in locations with tight constraints of whatever type, a substandard curve with appropriate signing could be considered when making improvements. The minimum advisory speed curve on your existing highways would be the signed value.

Maximum Superelevation

The ambient condition includes the maximum superelevation to be used when making highway improvements. Including this as a variable in defining the ambient condition gives the flexibility to determine the appropriate value based on local conditions.

Maximum grade

The setting of the maximum grade in the ambient condition statement may be done with the notion that the grade may be exceeded in a limited number of locations. For example, if a corridor had one section where the minimum grade attainable would be 8% due to difficult terrain, but a maximum grade of 6% would be attainable throughout the remainder of the corridor, the ambient condition could be set at 6%, with an exception to the grade for improvements in the section of difficult terrain. The exception would be stated in the project design criteria.

Lane width

This element should have little or no variation.

Shoulder width

Small differences in shoulder width can be tolerated. For example, a 1.8m or 2 m width would be viewed as being the same. Therefore which dimension is selected to be the ambient condition would depend, in part, on the extent of each current shoulder width in the corridor.

Setback

This refers to the setback for utility poles and other obstructions. The majority of existing highways were constructed before the application of clear zone as a standard. Thus clear zone is not part of the ambient condition.

Ambient Condition Rationale

The Ambient Condition Rationale is a document that explains the logical reasoning behind the ambient condition recommended by the Region. The following is a suggested layout for the Ambient Condition Rationale. The general content of each section of the document is set out below. It is meant as a guide to the preparation of the document, not an instruction.

Introduction

The introduction will include the purpose of the document and the background as to why ambient conditions are being determined and how they will be used. Reference to the discussion paper," Policy and Procedures regarding Project Identification, Scope, and Geometric Standards" and the source of the mandate to determine the ambient condition and to use them, the policy statement, should be included in the introduction.

Methodology

This section should outline the general procedures used to arrive at the ambient conditions. The measure used to determine the satisfactorily performance of the highway sections from the standpoint of safety and operations should be included.

Existing Conditions

This section deals with the data collected regarding the geometry and safety of the highway. The limitations of the data should be stated. This section of the Rationale should walk the reader through the process and reasoning behind decisions made, e.g. the separation of the corridor into sections of uniform terrain, etc.

Geometry

The first procedure in the ambient conditions exercise is to separate each highway corridor into sections that exhibit uniform characteristics of terrain, development, access and traffic volumes and composition. This portion of the document will outline these sections and include some dialogue explaining the reasoning behind the selection. Any unique situations would be noted.

The second procedure is to identify, within each section, sub-sections that have the same apparent design speed, lane width, and shoulder width. As with the previous procedure, some dialogue would be included and unique situations noted and explained.

Safety Data

This section would include the safety and operational performance statistics for each sub-section section as well as pertinent anecdotal information obtained from other sources. Comments regarding the highway sections with respect to safety and operation would be contained here. Notes regarding the accident severity ratio may be appropriate.

Discussion/Recommendation

This section of the document should explain the analysis of the existing conditions and the safety and operational performance record of the highway sub-sections, which lead to the recommendations. The section need not be long, but it must clearly explain the connection between the existing condition, the safety and operational performance data and the recommended ambient condition for each corridor or section. A suggestion is to discuss each element used to define the ambient condition. A “reduced version” of a spreadsheet for documentation of the recommended ambient condition is shown in Appendix A. For Ministry of Transportation and Highway Staff, the master Excel File for this spreadsheet is on the Standards and Design Public Drive:

FS_Public@HQA@TH, in the eng\standard\bulletin Sub-Directory

APPENDIX A

"Recommended Ambient Conditions"

Sample Form

Recommended Ambient Conditions

REGION: ______________________________ **Date:** ______________________

Highway	Section		Length	Design	Min advisory	Maximum	Maximum	Lane	Shoulder	Shoulder	Set back	Comments
Corridor	From	To		Speed	curve speed	superelevation	Grade	Width	width, paved	width, gravel	distance	

Recommended - Regional Manager of Professional Services ______________________________ Date:___________________

Approved - Chief Engineer ______________________________ Date:___________________

GUIDELINES FOR THE DEVELOPMENT AND PREPARATION
of the
PROJECT DESIGN CRITERIA
for
CONSTRUCTION AND REHABILITATION PROJECTS

Ministry of Transportation and Highways
British Columbia
Engineering Branch
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Introduction

The MoTH policy, *Corridor Ambient Geometric Design Elements Guidelines*, states that the Ministry will identify highway corridors, and within those corridors, determine geometric design elements that have been performing well in terms of safety and traffic operation. These geometric elements, collectively called the ambient condition, will be used as the basis for the design parameters for the improvement of poor performing sections of the highway corridor. Each region will determine the ambient condition for all the numbered highway corridors within their region. The ambient condition for each corridor will be outlined in the region's "Ambient Condition Rationale" document.

The ambient condition for a corridor is the basis for the design criteria to be used for all improvement projects in that corridor. The design criteria developed for each project are included in a Project Design Criteria Document; a document prepared for each project. The following guidelines are for the preparation of the Project Design Criteria Document.

Project Design Criteria Document

A Project Design Criteria Document will be produced for all highway design projects. This document will identify and define the problem(s) being addressed, the options considered, the scope of the project, and the development of the design criteria. Note that the Project Design Criteria Document is a required part of the project design file and subject to audit.

The design criteria are the geometric design limiting values that apply specifically to the project. The design criteria are determined for each individual project based on the ambient condition for the corridor where the project is located, taking into account the Ministry's rehabilitation and capital programs, project location and other relevant considerations.

The following outlines the topics to be addressed in the document and gives some guidance as to its content.

Problem Identification and Definition

Identify the operational or safety problem(s) to be addressed. Problem(s) may include such things as a high accident location, an operational problem at an intersection, or a lower than acceptable level of service. The requirement is that a specific problem(s) be identified.

Once identified, the problem is to be defined in sufficient detail to ensure that the correct problem is being addressed. This may require contact with local officials, police etc. An example: Drivers having off-road accidents at a sharp corner, the majority being off-road right through the corner, and a lesser number of off-road left from the other direction. The project design criteria document will outline the contacts made and the data gathered including its source and any limitations of the data, the analysis of the data, and the conclusions reached, i.e. the problem defined. The design project objectives must be clearly identified and defined.

Options Considered

All viable solutions should be considered, developed and compared. Viable options should not be eliminated from consideration without proper development and evaluation. Solutions for the example given above could range from extra signing and/or delineation to construction to reduce the curve radius. The document outlines the options considered, the evaluation of the options (some form of comparison) and the recommended solution.

Project Scope

Use the recommendations to determine the scope of the design project. The project limits should be restricted to that needed to carry out the engineering solution. The scope statement should include all known items and issues to be addressed in the design so as to minimize changes later.

Project Design Criteria

The development of the design criteria to be used in the project is a multi-stage procedure. The first step is to determine the ambient condition for in the project location. This information is contained in the region’s Ambient Condition Rationale. The existing conditions at the project location and adjacent to the project should be documented as these will be a factor in the final determination of the design criteria. The project design criteria are then developed based on the Ambient Condition defined for the corridor and other considerations, as explained in more detail below.

Use of the Ambient Condition

The design principle is to maintain the ambient condition for the corridor when rehabilitating or reconstructing a section of the corridor Thus the elements of the rehabilitated section will essentially be the same as those of the ambient condition set for the corridor. Any decision to vary from the ambient condition defined for the corridor is based on the following considerations:

Project Location

The location of the project may justify a variation from the ambient condition defined for the corridor. Two examples are presented.

First example: A project located at the interface between different ambient conditions may wish to use the ambient condition of the adjacent section.

Second example: There may be justification to raise specific elements of the highway geometry above that of the ambient condition if such action would be part of the engineering solution to the identified problem being addressed.

Rehabilitation and Capital Program

The anticipated rehabilitation and capital plans may influence the selection of the project design criteria. For example, if the rehabilitation program includes an upgrading such as widening the shoulders, then a project within the area should be constructed with the widened shoulders. Another example: if the anticipated capital or rehabilitation program over a number of consecutive years includes a continuing upgrade to the geometry of a portion of highway, then the project design criteria for construction within that portion of highway should be selected accordingly.

Justification

Carry out an economic or other appropriate analysis as required justifying any variation of the project design criteria from the ambient condition established for the corridor. Justification may be quantitative as well as qualitative. Quantitative evaluations include any objective that can be measured such as: benefit-cost ratio, reduced delays, or level of service improvements. Qualitative measures include such factors as: environmental impact, land access, or functionality.

Project Design Criteria Sheet

Complete the Project Design Criteria for design start-up. An Ambient Based Design Criteria sheet is attached in Appendix A. The project design criteria contains the following as a minimum. Additional items may be included if relevant to the project.

Design Speed

This is the design speed to be used for the project, with few exceptions the ambient condition.

Minimum Horizontal Curve

The minimum horizontal curve is derived from the design speed and the maximum superelevation to be used.

Minimum Stopping Sight Distance

The minimum stopping sight distance is derived from the design speed. There may be some variation in this value depending upon the selection of the variables used in the calculation. The current MoTH design standard assumes an eye height of 1.05 m and an object height of either 150 mm or 380 mm depending on the situation. These values apply to crest curves. Sag curve stopping sight distances, in areas where there is no illumination, are calculated using a headlight height of 600mm. In rare instances there may be justifiable reason for using values other than those contained in the Design Manual.

K factor: Sag and Crest

The K factor for both sag and crest curves is derived from the design speed and the associated sight distance variables.

Minimum advisory speed curve

This value will be as per the ambient condition except in rare cases such as an isolated curve in a corridor where the costs to achieve the ambient condition are prohibitive. In such a case the justification for the reduction and mitigative measures would be included in the documentation.

Maximum superelevation

This element will, in most cases, be the ambient condition. There is the flexibility to deviate with justification.

Maximum grade

The maximum grade stated in the ambient condition would be adhered to except in isolated cases where an isolated grade or short section of highway may justifiably differ from the ambient condition.

Lane width

This element should have little or no variation on through lanes. Auxiliary lane widths such as right and left turn lanes are determined independently.

Shoulder width, paved

There may specific project locations where there is a justifiable reason for suggesting a shoulder width other than that stated as the ambient condition. An example of such a location would be a project at the interface between different ambient conditions. The design of the wider shoulder may be justified. Conversely, shoulders adjacent to climbing lanes may be narrower.

Shoulder width, gravel

This element should have little or no variation on projects where there is a paved portion of shoulder. On projects without paved shoulder, the appropriate width should be based on the ambient condition for the corridor as well considerations similar to that for paved shoulders.

Setback

The setback is the distance that objects such as utility poles will be set back from the edge of the shoulder. This value is a minimum. Greater setbacks are desirable.

Other information:

Additional project specific information should be supplied to assist in the understanding of the project and the development of the design criteria. Any project information relevant to the understanding of the Project Design Criteria should be included. The following data should always be included.

- Traffic data:

  Examples of traffic data are: SADT, AADT, Design Hour Volumes, and Intersection turning movements.

- Level of Service

  The current level of service of the highway or intersection should be included.

- Truck Volume %

  The percentage of trucks, especially if they exist in unusually high numbers, can have a considerable affect on the design

- Design vehicle

  The design vehicle to be used for intersection design should be included. In some instances it may be prudent to include a design vehicle to which intersections are designed to accommodate with encroachment into adjacent lanes.

Approval Process

Ministry approval of the design criteria is required before the design starts and upon completion of the design. The project design criteria sheet is included in the project design criteria document, which in turn is an essential part of the Project design folder.

i) Design start-up:

- Project Design Criteria meet or exceed the Ambient Criteria:

  Recommended by: *One of the following* ____________-
  Regional Manager of Design/Highway Engineering
  Regional Manager, Planning
  District Highways Manager, if applicable

  Approved by: ________________________________
  Regional Manager of Professional Services

- Project Design Criteria below the Ambient Criteria:

  Recommended by: ____________________________
  Regional Manager of Professional Services

  Approved by: ________________
  Chief Engineer

ii) Design Completion:

- Achieved values meet or exceed the Project Criteria from Step i) above:

  Recommended by: ____________________________
  Manager of Design/Highway Engineering

  Approved by: ________________________________
  Regional Manager of Professional Services

- Achieved values below the Project Criteria from Step i) above:

  Recommended by: ____________________________
  Regional Manager of Professional Services

  Approved by: ________________________________
  Chief Engineer

Appendix A

AMBIENT-BASED PROJECT

Design Criteria

Form

Page___of__.
Date: __/__/__.
File No. :______________.

AMBIENT-BASED PROJECT

DESIGN CRITERIA

HIGHWAY ROUTE NAME/NUMBER : ____________________________________

L.K.I. INVENTORY SEGMENT: __________ From km: __________ To km: __________

CORRIDOR UPGRADING PROJECT: Yes: ☐ No: ☐

TOPOGRAPHY (Mountainous, Rolling, etc.) : ____________________________________

DITCH TEMPLATE MATERIAL : TYPE : __________

PROJECT DESCRIPTION : ____________________________________

____

	GEOMETRIC DESIGN ELEMENTS	EXISTING GEOMETRIC ELEMENTS			DESIGN GEOMETRIC ELEMENTS		
		PRIOR TO PROJECT LIMITS	WITHIN PROJECT LIMITS	BEYOND PROJECT LIMITS	AMBIENT CRITERIA VALUE	PROJECT CRITERIA VALUE	ACHIEVED CRITERIA VALUE
	A	B	C	D	E	F	G
1	Functional Classification :						
2	Design Speed :						
3	Posted Speed :						
4	Minimum Horizontal Curve Radius :						
5	Minimum Stopping Sight Distance :						
6	Min. "K" Factor : Sag V.C. :						
7	Min. "K" Factor : Crest V.C. :						
8	Maximum Superelevation :						
9	Maximum Gradient (%) :						
10	Lane Width(s) :						
11	Shoulder Width :						
12	Clear Zone Width :						
13	Right of Way Width :						
14	Current Traffic Volume : SADT :						
15	Design SADT/Design Hourly Volume :						
16	Truck Volume % :						
17	Accident Rate :						
18	Level of Service :						
19	Etc. :						
20							
21							
22							
23							

RECOMMENDED BY : ____________________________________

DESIGNER DATE

(See overleaf)

File No. :______________.

AMBIENT-BASED PROJECT

DESIGN CRITERIA

HIGHWAY ROUTE NAME/NUMBER : ______________________________________
L.K.I. INVENTORY SEGMENT: __________ From km: __________ To km: __________

1) Design Start-up Sign-off

PROJECT CRITERIA MEET OR EXCEED AMBIENT CRITERIA:

RECOMMENDED BY : ______________________________________
MANAGER OF DESIGN DATE

APPROVED BY : ______________________________________
MANAGER OF PROFESSIONAL SERVICES DATE

PROJECT CRITERIA BELOW AMBIENT CRITERIA:

RECOMMENDED BY : ______________________________________
MANAGER OF PROFESSIONAL SERVICES DATE

APPROVED BY : ______________________________________
CHIEF ENGINEER DATE

2) Design Completion Sign-off

ACHIEVED CRITERIA MEET OR EXCEED THE PROJECT CRITERIA (from Step 1 above):

RECOMMENDED BY : ______________________________________
MANAGER OF DESIGN DATE

APPROVED BY : ______________________________________
MANAGER OF PROFESSIONAL SERVICES DATE

ACHIEVED CRITERIA BELOW THE PROJECT CRITERIA (from Step 1 above):

RECOMMENDED BY : ______________________________________
MANAGER OF PROFESSIONAL SERVICES DATE

APPROVED BY : ______________________________________
CHIEF ENGINEER DATE